Desalination and Water Purification for Villages

by David Corbus 12/99

Background

As the world's population grows, so does the demand for potable water. Communities in arid coastal regions or regions with brackish groundwater, especially island communities, are already experiencing shortages of potable water. Many of these communities are small and remote, such as villages in arid Australia, coastal South America, and the Middle East, and on islands in the Caribbean and Mediterranean. While some of these communities can meet their water needs through demand management and conservation, for many of them desalination is the most appropriate solution.

Desalination consumes a large amount of energy. Many remote villages rely on costly, often limited supplies of diesel fuel for their energy needs; therefore, finding methods of using renewable energy to power the process is desirable. Desalination is an ideal application for a hybrid power system because the desalination system can be operated as a deferable load and can thus improve the load management of the hybrid system.

In addition to the need for desalination, remote populations require clean water, free of waterborne pathogens. There are several relatively inexpensive and widely available units that can be employed to perform this task.

Scope

Water Purification

The National Renewable Energy Laboratory (NREL) is life-cycle testing two different ultraviolet (UV) water disinfection units. UV disinfection is an effective treatment against most waterborne diseases. UV lamps (similar to a fluorescent light bulb) have low power consumption and are easily powered by small wind or photovoltaic systems. When the UV light output is sufficient, the water is disinfected. However, UV bulbs can emit visible light and still not emit enough UV light (which is not detected by the human eye) to properly disinfect water and most UV disinfection systems used in development projects do not include expensive UV light meters.

Typical UV bulb lifetimes are estimated to be between 7,000 and 10,000 hours, so a standard maintenance practice is to replace the bulb every several months or yearly, depending on the usage. NREL is currently cycling two UV water disinfection units under a typical daily cycle and monitoring the visible and UV light output as a function of time. The data from this experiment will be used to confirm the standard maintenance practice of bulb replacement.

Water Desalination

NREL researchers conducted a survey to examine the various ways in which renewable energy has been used for desalination, including photovoltaic-powered electrodialysis units, small-scale solar thermal-powered multiple-effect distillation systems, and direct-drive wind-powered reverse osmosis systems. The survey compared these systems based on capital cost, life-cycle cost, energy consumption, pretreatment requirements, and operational complexity.

NREL also sought to identify the possible ways in which renewable energy could be used for desalination in the future and to target areas of further research. Because few companies or communities will invest in an unproven application, ideas for key pilot projects that show the feasibility of renewable energy-powered desalination were analyzed.

Results

The survey overview was published in April 1997 and identifies several areas where further research is needed (see Status Table). Many pairings of renewable energy and desalination processes that seem quite viable in concept remain untested. These pairings are shown by empty spaces on the chart. Prototypes and pilot scale testing are needed to decide the viability of these systems and to learn how they compare with other combinations. Both photovoltaic- and wind-battery electrodialysis systems have been operated successfully. A mechanical wind-pump reverse osmosis system using pressurized water storage has been tested in Australia, but a similar electrical wind pump system has not been tested, although several researchers have concluded that electrical wind pumps are superior to mechanical pumps in high wind regimes. Recent improvements suggest that vapor compression is potentially the least expensive and lowest energy-consuming form of sea water desalination, but a renewable energy-powered system has not been tested.

NREL tested one of the more unique and promising combinations. An electrodialysis reversal (EDR) system was tested using a wind-electric power source. The EDR processed 1.1 liters per minute (lpm) of brackish water (900 parts per million) using an 850-watt wind turbine from Bergey Windpower Company attached to a 48-volt, 350-amp-hour battery bank. The power consumption for the test averaged 114 watts. The low (1.1 lpm) flow rate was due to a bypass valve leak on the system pump, which was discovered after the test was concluded. The system is part of a Bureau of Reclamation project focusing on desalination units suitable for use on Native American reservations and other remote locations in the United States. The Bureau has tested this system in Spencer Valley, New Mexico, on the Navajo reservation in a photovoltaic/battery design. In addition, the Solar Thermal Division of NREL initiated an investigation into small-scale solar thermal-powered multiple-effect distillation systems.

Planned Activities

NREL will continue to investigate vapor compression units suitable for use in villages.

Testing of independent hybrid photovoltaic/wind/battery systems with and without backup generators is continuing. A cooperative project between Australian researchers and NREL is being discussed with members of CASE/Australia, developers of a commercial prototype of a photovoltaic reverse osmosis system.

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